Assessment of autonomic nervous system function in nursing students using an autonomic reflex orthostatic test by heart rate spectral analysis

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Abstract. Nursing students experience academic demands, such as tests, theoretical and practical coursework, research activities, various aspects of professional practice, and contact with health professionals and patients. Consequently, nursing students face numerous types of stress, and increased stress levels contribute to physical and psychological distress in nursing students. The aim of the present study was to investigate the autonomic nervous system function of nursing students by assessing active standing load using the autonomic reflex orthostatic tolerance test, which enables quantitative analysis of dynamic autonomic nervous system function. The autonomic nervous system activity in the resting state was low in fourth-year students, they had parasympathetic hypotension, and there was a tendency towards higher sympathetic nervous system activity of fourth-year students compared with first-, second- and third-year students. In the standing state, there was a trend towards a higher autonomic nervous system activity response of fourth-year students compared with first-, second- and third-year students. These results suggest that stress may influence autonomic nervous activity in fourth-year nursing students. By correcting stress in fourth-year nursing students, it may be possible to prevent the development of health problems.

Introduction

The autonomic nervous system coordinates bodily functions to ensure homeostasis (cardiovascular and respiratory control, thermal regulation, gastrointestinal motility, urinary and bowel excretory functions, reproduction, and metabolic and endocrine physiology) and adaptive responses to stress (1). Autonomic responses to psychological stress induce activation of sympathetic nerves with inhibition of the parasympathetic nervous system and adrenocortical hormone release to the heart, leading to increased heart rate, cardiac output and blood pressure (2). Psychological factors contribute to physiological processes (such as sweating, cardiovascular and gastrointestinal arousal) via the autonomic nervous system (3). Stress is a major contributor to psychosocial and physical pathological conditions (4).

Nursing students experience academic demands, such as tests, theoretical and practical coursework, research activities, various aspects of professional practice, and contact with health professionals and patients. Consequently, nursing students face numerous types of stress (5). Thus, increased stress levels contribute to physical and psychological distress in nursing students (6-8). There is a concern that the added demands of modern nursing programs place the students under greater pressure due to competing demands (9). Therefore, we hypothesized that high-grade students faced greater stressors, and consequently had abnormal functioning of the autonomic nervous system.

The aim of the present study was to examine the functioning of the autonomic nervous system in nursing students by assessing active standing load using the autonomic reflex orthostatic tolerance test that enables quantitative analysis of dynamic autonomic nervous system function.

Materials and methods

Design and participants. There were 121 nursing students (22 first-, 35 second-, 23 third- and 41 fourth-year students) enrolled at the Kyoto Prefectural University of Medicine (Kyoto, Japan). These data are >70% of stable R-R intervals without noise. There were 3 (2.5%) males and 118 (97.5%) females, and the average age was 20.6 ± 1.8 years (range, 18-33 years). The investigation was carried out between October 1, 2014 and January 31, 2015.

Data collection and analysis. For measurements of the autonomic nervous system functions, a heart rate variability

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Table I. Autonomic nervous system functions of the resting state in different student nursing years.

Variables	First year, n=22	Second year, n=35	Third year, n=23	Fourth year, n=41	Wilcoxon/Kruskal-Wallis testing result
CVRR	5.80±1.53	5.50±1.55	5.68±1.75	5.02±1.37	First vs. fourth; P=0.017
LF/HF	2.97±2.34	2.80±2.44	2.10±1.97	3.69±3.57	NS
CCVHF	2.46±0.75	2.36±0.77	2.73±0.89	2.23±0.85	Third vs. fourth; P=0.015
Heart rate	73.72±9.50	70.82±8.90	72.70±11.42	73.18±8.98	NS

Data are average ± standard deviation. NS, not significant; CVRR, coefficient of variation of R-R intervals; LF, low-frequency; HF, high-frequency; CCVHF, coefficient of component variance for HF.

Table II. Autonomic nervous system functions of the standing state in different student nursing years.

Variables	First year, n=22	Second year, n=35	Third year, n=23	Fourth year, n=41	Wilcoxon/Kruskal-Wallis testing result
ΔCVRR	2.57±2.13	2.38±2.56	2.76±1.71	3.35±2.09	NS
ΔLF/HF	4.20±7.47	3.94±7.88	3.60±4.39	2.60±3.61	NS
ΔCCVHF	0.57±0.41	0.46±0.40	0.48±0.65	0.38±0.71	NS
Heart rate	7.55±4.27	7.47±4.43	7.48±3.45	8.03±4.53	NS

Data are average ± standard deviation. NS, not significant; CVRR, coefficient of variation of R-R intervals; LF, low-frequency; HF, high-frequency; CCVHF, coefficient of component variance for HF.

analysis method was used (10). Heart rate and autonomic nervous activity were measured. Electrocardiogram measurements were obtained in a sitting position for 2 min, in a standing position for 2 min and in a resting position for 1 min for autonomic reflex orthostatic tolerance test. Real-time analysis was performed using heart rate variability analysis software by Crosswell Co., Inc., (Yokohama, Japan). The coefficient of variation of R-R intervals (CVRR) obtained from electrocardiograms were divided into high-frequency (HF) and low-frequency (LF) components by power spectrum analysis to evaluate the autonomic nervous activity. The HF component reflects parasympathetic nervous activity, while the LF/HF reflects sympathetic nervous activity. Coefficient of component variance for HF (CCVHF) reflects the parasympathetic nervous index, and CVRR as the variability of overall autonomic nervous system activity. ΔCVRR was used as the response of the autonomic nervous system. ΔLF/HF was used as the sympathetic nervous system function in the standing position. ΔCCVHF was used as the parasympathetic nervous system function in the sitting position. The differences between the groups of each parameter were analyzed using the Wilcoxon/Kruskal-Wallis test. A two-tailed P<0.05 was considered to indicate a statistically significant difference.

Ethics consideration. The study received Ethics approval from the Institutional Review Board of the Kyoto Prefectural University of Medicine (notice no. of determination: ERB-E-76, 2014). The students received an information sheet that explained the purpose of the study and methods, and were provided with assurance that participation was voluntary and

that their personal information would be kept confidential during and following the study.

Results

Resting and standing states. The results of every student year for resting state are shown in Table I. The activity of the autonomic nervous system (CVRR) of fourth-year students was lower compared with first-year students (fourth-year students, 5.02±1.37; first-year students, 5.80±1.53; P=0.017). There was a trend of the sympathetic nervous system activity (LF/HF) of fourth-year students to be higher compared with other student years (fourth-year students, 3.69±3.57; third-year students, 2.10±1.97; P=0.08). The parasympathetic nervous system activity (CCVHF) of fourth-year students was lower compared with third-year students (fourth-year students, 2.23±0.85; third-year students, 2.73±0.89; P=0.015). The results for every student years for the standing state are shown in Table II. There was a trend of ΔCVRR of fourth-year students to be higher compared with other student years (fourth-year students, 3.35±2.09; second-year students, 2.38±2.56; P=0.10). There was a trend of the sympathetic nervous system response (ΔLF/HF) of fourth-year students to be lower among the other student years.

Autonomic nervous system functions. The results of the autonomic nervous system functions of the resting state comparing fourth-year students with first- to third-year students is shown in Fig. 1. The activity of the autonomic nervous system (CVRR) of fourth-year students was lower compared with first- to third-year students (fourth-year students, 5.02±1.37;
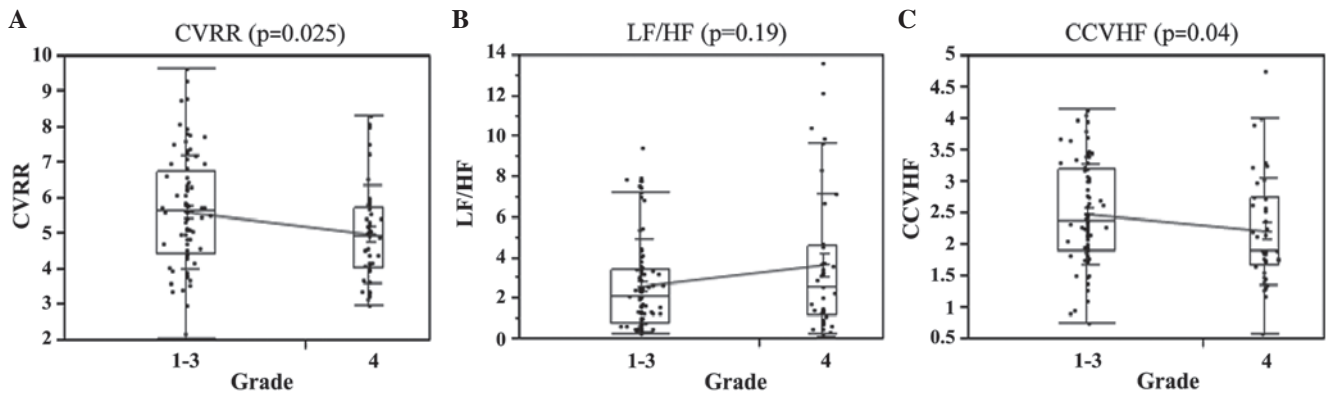
Figure 1. Autonomic nervous system functions at the resting state comparing fourth-year nursing students with first- to third-year nursing students. (A) CVRR (P=0.025), (B) LF/HF (P=0.19) and (C) CCVHF (P=0.04). CVRR, coefficient of variation of R-R intervals; LF, low-frequency; HF, high-frequency; CCVHF, coefficient of component variance for HF.
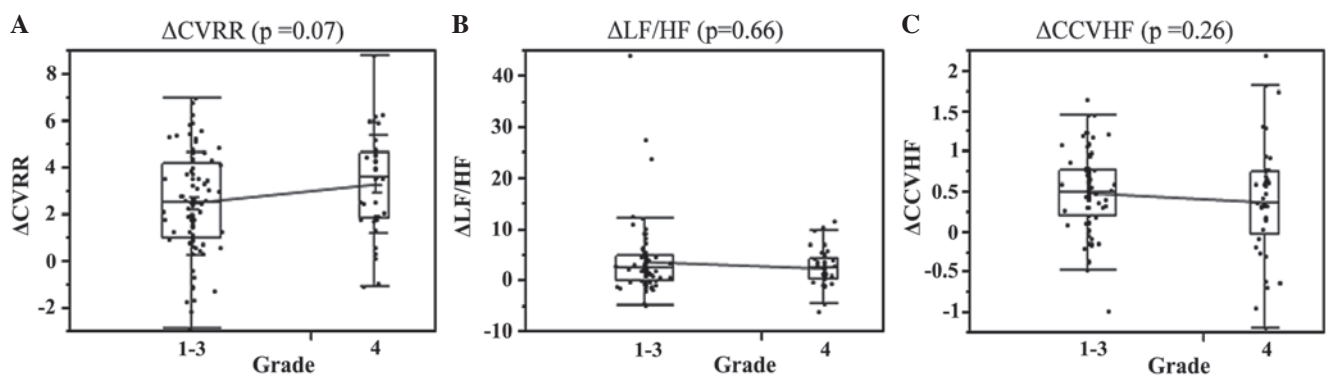

Figure 2. Autonomic nervous system functions at the standing state comparing fourth-year nursing students with first- to third-year nursing students. (A) ΔCVRR (P=0.07), (B) ΔLF/HF (P=0.66) and (C) ΔCCVHF (P=0.26). CVRR, coefficient of variation of R-R intervals; LF, low-frequency; HF, high-frequency; CCVHF, coefficient of component variance for HF.

first- to third-year students, 5.63±1.59; P=0.025). There was a trend of the sympathetic nervous system activity (LF/HF) of fourth-year students to be higher compared with first- to third-year students (fourth-year students, 3.69±3.57; first- to third-year students, 2.65±2.29; P=0.19). The parasympathetic nervous system activity (CCVHF) of fourth-year students was lower compared with first- to third-year students (fourth-year students, 2.23±0.85; first- to third-year students, 2.49±0.81; P=0.04). The results of the autonomic nervous system function in the standing state comparing fourth- to first- to third-year students is shown in Fig. 2. There was a trend of the ΔCVRR of the fourth-year students to be higher compared with first- to third-year students (fourth-year students, 3.35±2.09; first- to third-year students, 2.54±2.20; P=0.07). ΔLF/HF and ΔCCVHF were not significant between fourth- and first- to third-year students.

Discussion

The present study showed that fourth-year student autonomic nervous system activity in the resting state was low, there was parasympathetic hypotension and there was a trend of the sympathetic nervous system activity of fourth-year students to be higher compared with first- to third-year students. In the standing state, there was a trend of the autonomic nervous system activity response of fourth-year students to be higher

compared with first- to third-year students. Autonomic responses to psychological stress induced the activation of sympathetic nerves with inhibition of the parasympathetic nervous system (2). In the standing state, there were several cases in the fatigue state with a higher autonomic nervous system activity response (data not shown). The present results suggest that stress may influence autonomic nervous activity in fourth-year nursing students.

Long sleep hours and a regular diet are considered the backbone of a healthy student lifestyle. Sleep decreases sympathetic nerve activity (2). From our previous study (11) it was revealed that fourth-year nursing students had longer studying hours with less sleeping hours. Therefore, the clinical training and study hours had an effect on the life rhythm of fourth-year nursing students. Additionally, lifestyle is affected by stresses, including clinical nursing practice and studying for a national board examination.

The stress response is mediated by the stress system, which is located in the central nervous system and peripheral organs. The main stress system includes the hypothalamic pituitary axis and the systemic sympathetic adrenomedullary systems (4). Stress is a major contributor to psychosocial and physical pathological conditions (4). Chronic stress can cause physical, behavioral and/or neuropsychiatric manifestations, such as anxiety, depression, executive and/or cognitive dysfunction, and sleep disorders such as insomnia (4). Increased levels

of corticotrophin-releasing hormone and/or stress system abnormalities have been reported in behavioral and neuro-psychiatric disorders, such as anxiety, depression and eating disorders. Low corticotrophin-releasing hormone activity has also been implicated in depression (4). All these disorders are associated with dysfunction of the stress system (4).

Studying stress among nursing students is important as this condition is associated with academic performance, which can influence the quality of care in their future professional life. It is necessary to design effective prevention and intervention strategies for mental health problems in nursing students through stress management. Determining how stress occurs among nursing students is an essential step in preventing and reducing the progression of health problems to more severe states. There is widespread agreement that preventing health problems is a better strategy compared to treating them after they become apparent (12,13). Interventions aimed at reducing the risk of health problems by treating autonomic nervous system dysfunction may produce better results, although guidance in effective stress management may be essential.

The limitations of the present study were that it included a relatively small number of participants and that the context was confined to a particular geographic location. However, the study offers certain valuable insights into the autonomic nervous system dysfunction among nursing students.

In conclusion, the present study confirmed that the activity of the autonomic nervous system in the resting state in fourth-year nursing students was low, there was parasympathetic hypotension and there was a trend of the sympathetic nervous system activity of fourth-year students to be higher compared with first- to third-year students. In the standing state, there was a trend of the autonomic nervous system activity response of fourth-year students to be higher compared with first- to third-year students. By correcting stress in fourth-year nursing students, it may be possible to prevent the development of health problems.

Acknowledgements

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